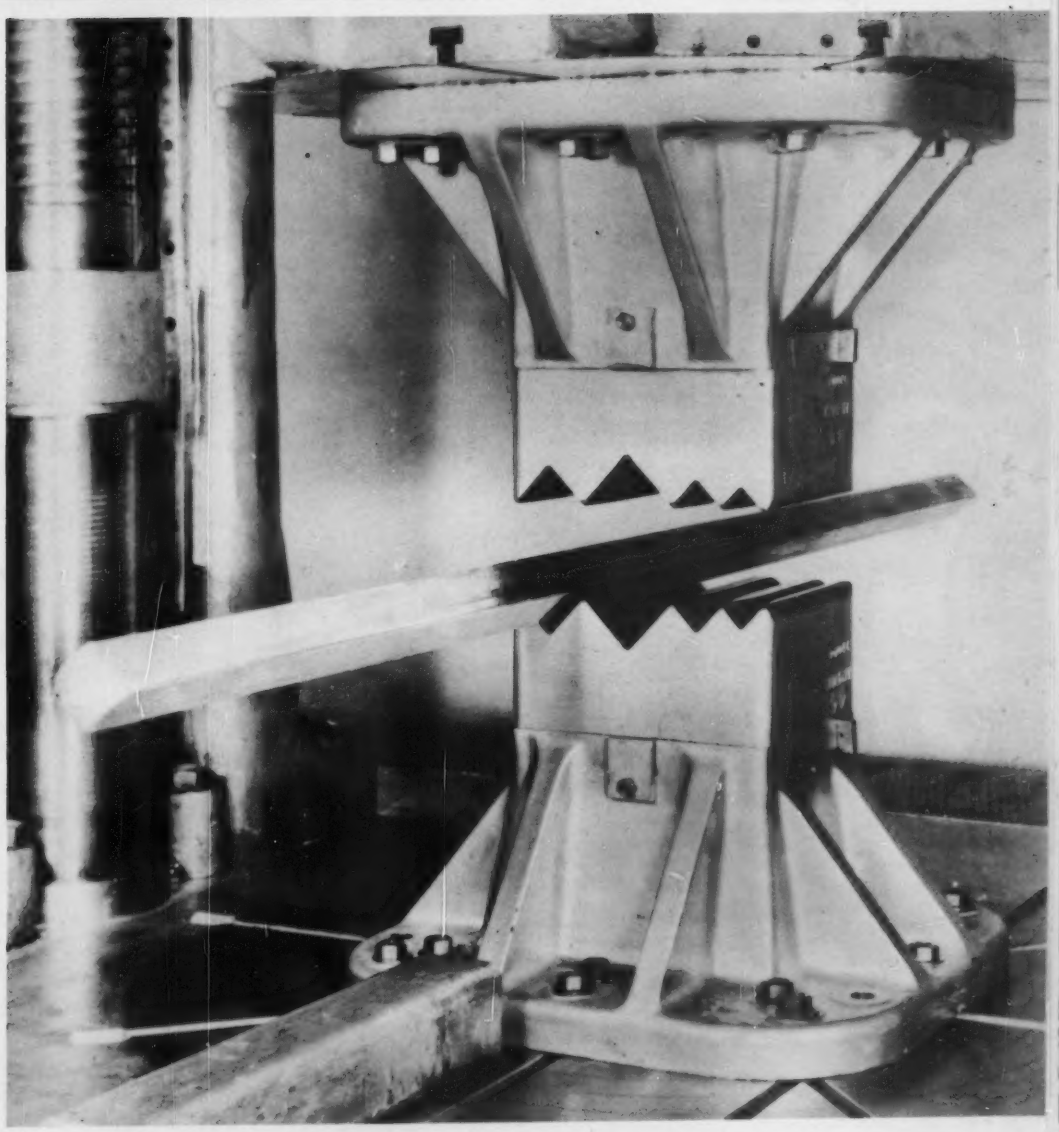
TECH ENGINEERING NEWS



APRIL · 1940

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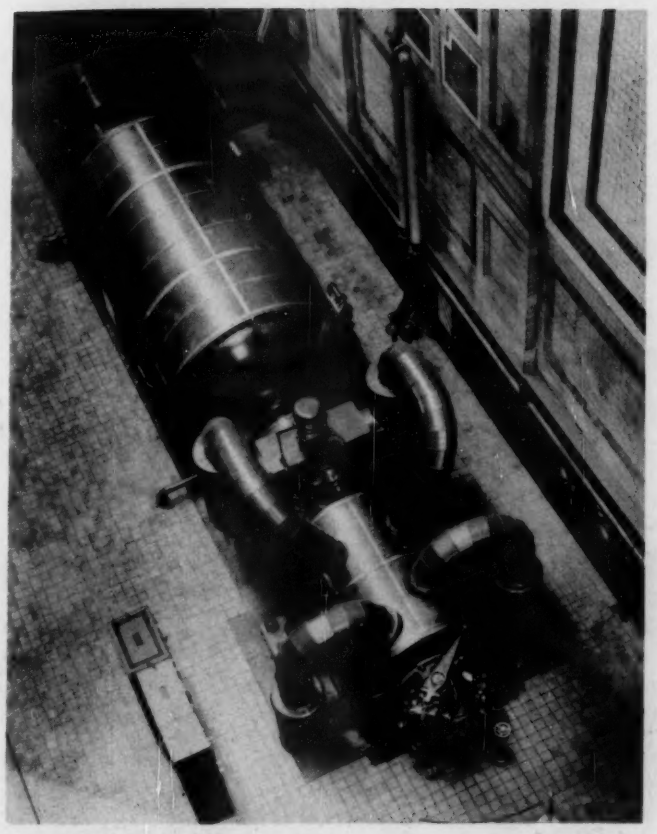

General Electric

OUR COVER THIS MONTH
An aluminum ingot undergoes some of the machine's press forging possibilities

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An interesting study in black-and-white made from a miniature camera Kodachrome via an intermediate negative

COLOR FILM

NEW TREATMENT PROCESS GIVES ACCURATE REPRODUCTION

By DR. WALTER CLARK

KODAK RESEARCH LABORATORIES

THE earliest color photograph was made only twenty-two years after the introduction of the first practical photographic process by Daguerre. It was used in 1861 by Clerk Maxwell, the famous British physicist, in connection with some experiments he was making on a theory of color vision. He demonstrated that most of the colors of nature could be matched in hue by appropriate mixtures of red, green, and blue light — the so-called "primary colors." Maxwell made photographs of some colored ribbons on iodized collodion plates exposed through filters consisting of solutions of inorganic salts colored red, green, and blue. Positive transparencies from these negatives were projected in register on to a screen through the same filters by which the negatives were made, and a color picture resulted. The original positives are still in existence in London, and recently a good color print has been made from them.

Eight years after Maxwell's experiment, a Frenchman, Ducos du Hauron, published a small book in which he described the principles of practically every color process which has since been attempted. This achievement, and that of Maxwell, are extraordinary, because photographic dry plates had not then been invented, and materials which responded with any ease to the colors of the spectrum other than blue were unknown. It was not, in fact, until good color sensitizing of plates had been discovered, that any practical process of color photography could be made available. In the early days, apparatus was used which duplicated Maxwell's experiment in a more convenient manner, but the greatest advance was not made until 1907, when the Lumière Autochrome plate, first of a series of so-called screen-plate processes, was put on the market.

The principles of these screen-plate processes had been described by du Hauron. They, and the Maxwell method, are the so-called "additive" processes of color photography, designated in this manner because they depend for their functioning on the adding together of light of the three primary colors. Du Hauron also described the basic principles of another system of color photography, the "subtractive" method. In this, negatives are also made by red, green, and blue light, but they are printed in color and the prints are laid one over the other in register. The colors used are those resulting from subtracting the colors of the primaries from white light. The print from the negative made by red is printed in a dye or pigment having the color of white minus red, which is blue-green, sometimes called "cyan." That from the green negative is printed in magenta, and that from the blue negative in yellow. Superposition of the cyan, magenta, and yellow positives, either on paper or as transparencies, gives good color reproduction of the original.

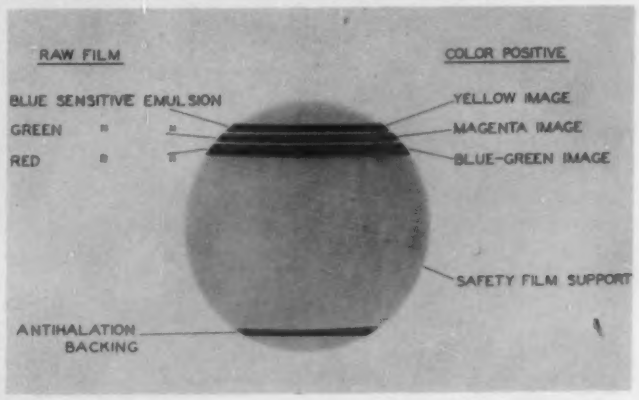
The first method of using the subtractive system consisted in actually making three separate negatives, from them printing three colored positives, and bringing them together in register. This is the method actually employed at the present time in making color prints on paper by such processes as the Wash-off Relief, Carbro, etc., and in the Technicolor system of motion pictures in color.

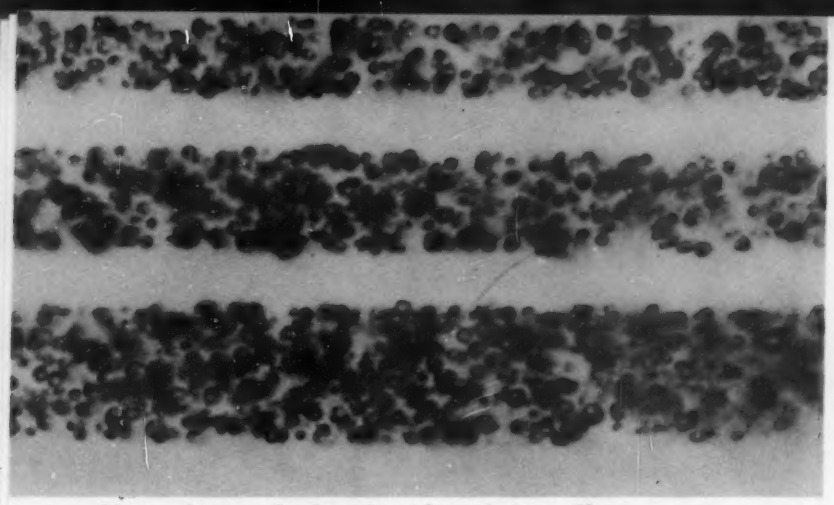
At the close of the War, the Kodak Research Laboratory turned its attention to the development of a practical process of amateur cinematography. This was satisfactorily accomplished, and made available as the Ciné-Kodak Process in 1923. Once the system had been worked out by which amateurs could make their own movies, the attention of the Laboratory was directed toward the development of making those pictures in color, and in 1928 the Kodacolor process was put on the market. This was an additive process, but had certain limitations, particularly in that filters were used which involved much loss of light, the projected picture showed a line pattern, and wide-aperture lenses had to be employed.

The ideal color motion picture film process would be one in which the photographer could use any camera, expose the film under normal conditions, and project it in any ordinary projector without special attachments. This was achieved in a system made available in 1935 as the Kodachrome process. Since that time, it has been put out in the form of 16 mm. and 8 mm. motion picture film, 35 mm. film for miniature cameras, and in all the common cut sheet sizes.

Kodachrome is a subtractive process, but it is unique in the manner in which the three separation negatives are made, and in the way in which they are converted to give the final dye transparency. Instead of using three separate negative films, as is customary in three-color photography by other systems, Kodachrome

An enlarged cross-section of the finished film





Photomicrograph of section of coatings on film

film is coated with three emulsions, one above the other, so made that color separation is effected in the depth of the multiple coatings. The emulsion nearest the film support is sensitive to red light; over this is coated a clear gelatin layer, and on that an emulsion which responds to green. Above this is another gelatin layer, and on top a coating which responds to blue. The two lowest emulsions, sensitive to green and red, also possess the natural sensitivity of all emulsions to blue. In Kodachrome film, therefore, a yellow dye is used in one of the upper layers to prevent blue light penetrating to the green- and red-sensitive layers. The total thickness of all five layers is no greater than that of the single coating on a black-and-white reversal film.

When the film is exposed in the camera, the blue, green, and red sensations from the original subject are recorded in the appropriately sensitized layers. The film is then developed so as to produce dye images in each layer, of colors complementary to the color of the light by which the layers were exposed. For instance: the image in the bottom, red-sensitive layer, is converted to a blue-green or cyan positive; that in the middle, green-sensitive layer, is converted to a magenta positive; and that in the upper, blue-sensitive layer, to a yellow positive.

There are two primary steps involved in this. The first one is to produce positive images by the well-known reversal process. This consists in developing the film to a negative, removing the negative silver in a bleach bath, and then reconverting the residual undeveloped silver salts to a positive image by uniform exposure and redevelopment. The second characteristic consists in making this redeveloped positive in the form of dyes, instead of in black silver, such as is done in the normal black-and-white reversal process.

In order to effect this, special types of developer known as "coupler developers" are employed. The solutions contain developing agents, for instance, of the paraphenylenediamine series, together with so-called "dye coupling agents." When the exposed film is developed, a silver image is formed in the usual way, but the developer becomes oxidized in this process to give an oxidation product in the actual position in which the silver is being produced. The coupling agents present in the developer solution combine with this compound to produce dyes.

In the processing of the film, three types of coupling agent are used to form cyan, magenta, and yellow dyes by combination with the oxidation product of a common developing agent. Steps are taken to ensure that the cyan dye forms only in the bottom layer, magenta dye only in the middle layer, and yellow dye only in the top layer.

In order that the final color photograph may be a faithful reproduction of the original, it is necessary that the three dyes be of the correct hue and saturation, and that they are present in the proper proportions in the three layers. This is ensured by appropriate selection of the developers and coupling agents, and by careful choice of the three superimposed emulsions to ensure that they have the correct color sensitivities, contrast, and other characteristics of quality, and the appropriate relative speeds. They must also be coated in the proper thicknesses, and extremely uniform throughout the length of the film.

It will be clear from this that an enormous amount of research was necessary to ensure that every characteristic was correctly selected, and that all of them were properly balanced in relation to one another. It is only the great strides which have been made in the knowledge of photographic emulsion manufacturing and coating technique, and the results of intensive research on photographic sensitizing dyes which have made satisfactory films possible. In addition, there has had to be much research done on the organic chemistry of developing agents and coupling components, as well as on the stability and other characteristics of dyes. Further, very precise chemical and photographic controls have had to be established for checking the processing of the film at frequent intervals. The processing of all types of Kodachrome film is done continuously on automatic machinery, in which the film is carried mechanically through series of baths, in each of which it receives exactly the correct treatment. Exhaustion of the solutions by use is compensated for by carefully controlled replenishing systems. The entire operation is so carried out that exposed films are fed into one end of the machine, and appear at the other in the form of dry transparencies in full color, and ready for projection or viewing.

The images on Kodachrome film are of very fine grain. This is partly due to the fact that they are in the form of dyes, but mainly to their being produced by the reversal process. In the case of reversal films, the largest grains of silver bromide, which are the most sensitive to light and therefore first affected by exposure in the camera, are developed and then removed in the bleach bath. This leaves the finer grains to be developed in the second stage of the process and give rise to the final positive. In addition to fine grain, Kodachrome film also possesses high resolving power, which is partly due to the extreme thinness of the layers, and the fact that the dyes do not wander from the site in which they are produced. Further, emulsions inherently giving good resolution are used. The speed of the film is adequate to enable moderate lens apertures to be employed. For instance, in summer sunlight in the temperate zones, an aperture of $f/8$ provides a good basic exposure for average scenes photographed in an amateur motion picture camera.

Kodachrome film is made in two varieties in each of its forms, to permit exposures to be made by sunlight and by artificial light. Since proper color rendering in a color film can only be achieved by precise balance of the sensitivity and contrast of the emulsions and the color and other characteristics of the dye positives, in relation to the spectral quality of the light source, it is necessary to select specific qualities of illumination and make and process the film to suit them. It would not be a practical matter to make different films or use different processing methods to satisfy all colors of daylight and all kinds of artificial light. A color temperature change of 100°K. in electric lamps can readily be detected by its effect on the color balance of a color film. Kodachrome film is, therefore, balanced for specific qualities of illumination. In the case of the daylight types of film, this corresponds to average summer sun-

light about the middle of the day in the temperate zones. The films intended for use by artificial light are balanced for Photoflood lamps in the case of 16 mm. and 8 mm. amateur motion picture films and the miniature camera films, and for a color temperature of 3200°K. for the cut sheet types of film. These two qualities are selected to correspond with the average types of lighting used in amateur and commercial indoor color photography. If the color quality of the light differs markedly from that for which the films are balanced, correction may be achieved by the use of appropriate compensating filters over the camera lens. It is not possible to obtain good color rendering by using light sources, such as mercury arcs, which have a discrete line spectrum. The spectrum must be continuous and approximate closely to that of a black body.

Clearly, the light by which the color transparencies are viewed also determines the color balance of the picture. Kodachrome film is so processed that when the films are projected or viewed by high efficiency tungsten filament electric lamps, the colors resemble those of the original subject as seen in daylight.

The applications of Kodachrome are legion. There are relatively few photographs which do not have more appeal when made in color as compared with black-and-white, and many subjects can only be satisfactorily rendered in color. At the present time there is a certain limitation in that the best color photographs are in the form of transparencies for projection or viewing on an illuminator, but very good color prints on paper can be made by the Wash-off Relief, Carbro, and other processes, starting from Kodachrome transparencies. Many of the commercial color advertisements printed in magazines and papers are reproduced from Kodachromes, because they have the great advantage that the originals can be made in ordinary cameras with short exposures. For visual education, scientific and technical illustration, and medical photographs, Kodachrome transparencies have been very extensively employed. The majority of amateur movies are now made in color, and large numbers of miniature camera films are made in Kodachrome for projection in small slide projectors. To assist in this, miniature Kodachromes are returned from processing ready mounted in durable, unbreakable cardboard mounts. Duplicates of Kodachrome films can be obtained, and are much used in the commercial and visual education fields. Good black-and-white prints can be made from Kodachromes via an intermediate negative, or directly by the reversal process.

The introduction of Kodachrome started a new era in photography, by making the use of color simple for the amateur, the commercial illustrator and the scientist. It has inaugurated what may well become a revolution in photography — the change-over from black and white to color. To the technician, it appeals as a fine example of coöperation between coördinated research and manufacture. For the user, it provides a simple means of obtaining faithful rendering of his subject in its true values.

Section of machine for processing Kodachrome *Eastman Kodak*

FASTER LENSES

THIN TRANSPARENT FILMS IMPROVE PHOTOGRAPHIC LENS EFFICIENCY

By WILLIAM R. WILCOX, '42

THE recent announcement of two different methods to make "invisible glass" has suggested many applications to instruments in the optical field. At present, the general interest in photography has brought the importance of the new process with respect to camera lenses into the limelight. However, the principles of the reduction of reflection to an absolute minimum are perhaps more important, if less spectacular, in connection with the more complicated optical instruments which contain a greater number of air-glass surfaces.

Although the idea of treating glass surfaces with thin transparent films to step up the transmission of light through the glass is not new, practical processes by which this is accomplished are relatively recent. K. B. Blodgett of the General Electric Company and C. H. Cartwright and A. F. Turner of the Massachusetts Institute of Technology simultaneously announced two different methods less than two years ago.

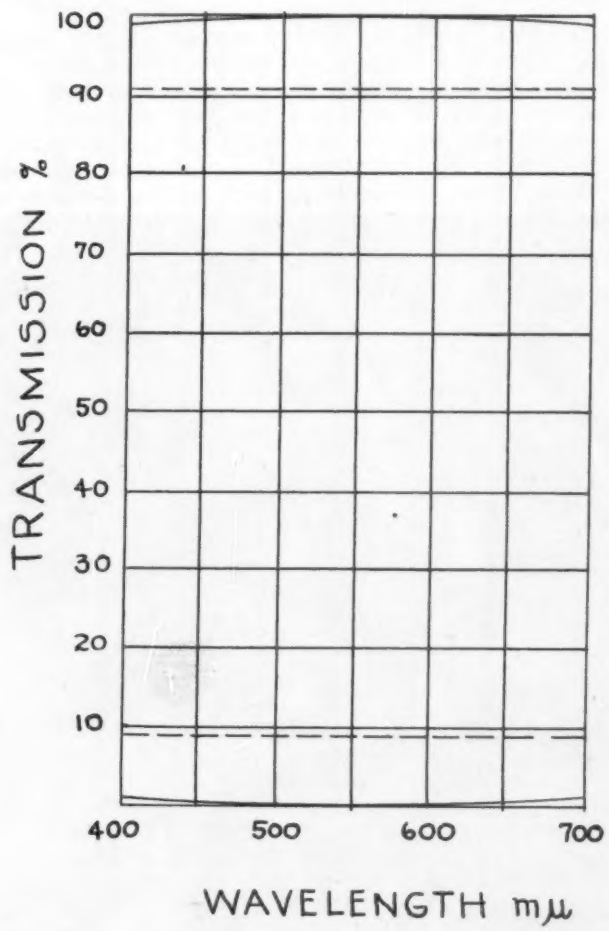


Figure 1. Transmission at every wave length for a single glass plate (n=1.58) treated on both sides with calcium fluoride by the Cartwright-Turner method. The dotted lines represent the transmission of light through the untreated plate.

Miss Blodgett has devised a method for applying layers of metal "soaps" to glass, one molecular layer at a time. By adding a small quantity of stearic acid to water which contains calcium ions and adjusting the acidity to the proper value, a film of calcium stearate just one molecule thick is formed on the surface of the liquid. This film is then deposited upon carefully cleaned glass by raising the glass slowly out of the water, and successive films are applied by repeating the process. Any free acid which remains in the film is then dissolved out with benzene or some other suitable solvent. Forty of these films are necessary to eliminate the reflection of yellow light of wave length 589 millimicrons.

Doctors Cartwright and Turner have worked out a method based on entirely different principles. The glass to be treated is carefully cleaned and placed in metal racks over a small heater. A large vacuum jar is placed over the specimens and the space evacuated. The heater is then turned on and the material for the film is evaporated into the space, where it deposits on the glass surfaces. The process is controlled by observing the characteristic color changes of the film which indicate the thickness of the film at any moment. In this method, a film .000012 centimeter thick is necessary to eliminate the reflection of yellow light of wave length 589 millimicrons.

The application of the film to glass will theoretically eliminate surface reflection for one color (or one wave length) when reflection from the air-film surface and that from the film-glass surface interfere to cancel one another. This is accomplished by making the optical thickness of the film equal to one quarter wave length and using a film with effective index of refraction equal to the square root of that of the glass. Under these conditions, the light waves reflected from the air-film surface will be 180 degrees out of phase with the light waves which are reflected from the film-glass surface and the amplitudes of the two reflected waves will be equal.

The most important property of the films is, of course, their ability to reduce surface reflection and thereby increase transmission. Figure 1 shows the transmission at every wave length in the visible spectrum for a single glass plate treated on both sides with sodium fluoride by the Cartwright-Turner method. Of primary practical importance is the ruggedness of

the film. Those produced by Doctors Cartwright and Turner appear to be sufficiently tough for most requirements while those produced by Miss Blodgett are reported fragile. The permanence of the coating is especially important in the treatment of camera lenses with these films.

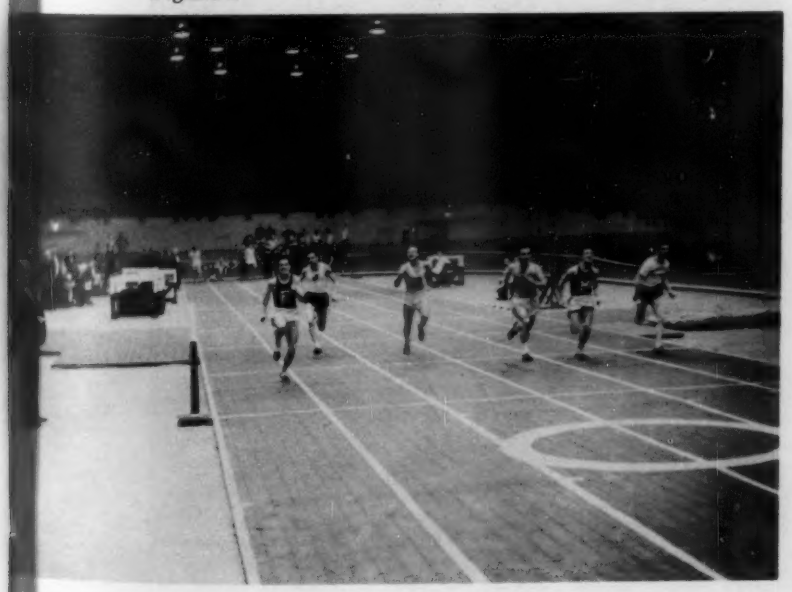
It is well known that faster and more highly corrected camera lenses require a large number of separated elements. Each separated element reflects about ten per cent of the incident light. In consequence, good camera lenses will ordinarily have transmissions of only about sixty per cent. The incident light reflected from each air-glass surface is, unfortunately, not merely lost. About five per cent of this light is reflected again from other surfaces. Some of it strikes the photographic plate where it supersensitizes the emulsion, in some cases produces a flare pattern, and in extreme cases produces a ghost image.

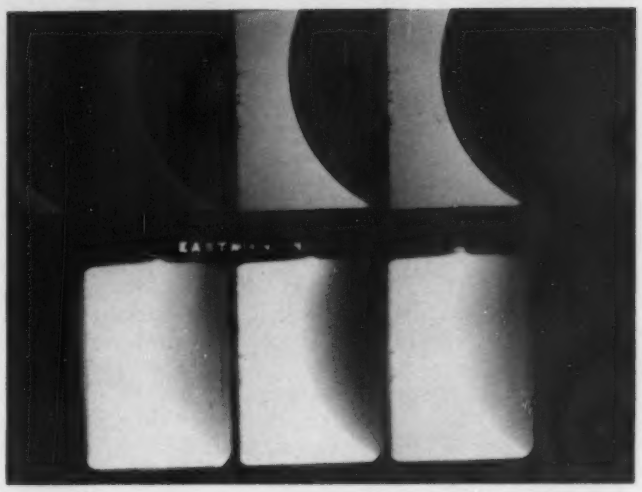
Dennis Taylor observed in 1892 that tarnishing of camera lenses leads to an increase of their effective speed. The tarnished surface of the glass elements of high refractive index diminished the reflection of light from the air-glass surfaces and thereby increased the transmission of the whole camera lens. Various methods were devised for artificially tarnishing glass but apparently the results were not sufficiently effective to justify their adoption by the manufacturers of camera lenses. It is now evident that the tarnish is actually a film of a transparent material having a lower index of refraction than that of the glass. To be most effective, such a film must fulfill the above named specific requirements.

In order to have the film index of refraction equal to the square root of that of the glass, a film of abnormally low index of refraction is required. Even when this condition is satisfied only approximately, however, a marked decrease in the reflection from glass is possible. The second requirement, that the film must have an optical thickness of one-fourth of the wave length of the incident light, is of paramount importance, although it may be fulfilled exactly for only one wave length, the reflectance is greatly reduced throughout the spectral range used for most visual and photographic purposes. These two conditions can be satisfied rather well by evaporated films of the metallic fluorides deposited on glass in vacuum.

In an actual experiment, Dr. Cartwright treated an *f*:2 photographic lens having five separated elements

Figure 2





Prof. D. Menzel, Harvard Observatory

Figure 3. Coronagraph picture of sun, showing improvement effected by treated lens.

with evaporated fluoride to decrease the reflection from all air-glass surfaces. Pictures were taken under carefully controlled conditions before and after the lens was treated. Films of calcium fluoride were used. The reflection from the separate elements was observed during the formation of the film and the evaporation of the calcium fluoride was stopped when the reflection of white light appeared to be a minimum.

A group of test objects was photographed with various exposure times and apertures of *f*:2 and *f*:3.5 (Fig. 4). The test objects consisted of a large white paper, a large black paper, a special set of nine rather large grays, an Eastman gray scale, Eastman color patches, a black-and-white drawing, and a detailed color chart for ceramic resistors. Two seven watt lamps placed one meter in front and one meter on either side of the test objects served for illumination. The current through the lamps was kept constant by means of a Variac and read with a meter. Exposure times from five to eighty seconds were measured with a stop watch. Pictures, before and after the lens was treated, were taken on parts of the same roll of 35 millimeter Eastman Panatomic X. The pictures were all developed simultaneously. The plates were measured for density. Contact prints, made simultaneously of all the negatives, served for additional comparisons. Although attempts were made to control the enlargements used herewith as illustrations, some variations undoubtedly occur because the enlargements could not be made simultaneously.

The direct photographs of a bright light, as shown in the lower two pictures in the accompanying illustration, are probably the most striking. The ghost image of the light disappeared and the flare was greatly reduced in the photographs with the treated lens. Ghosts and flare originate from light that has been reflected at least twice inside the lens. Consequently, in treated lenses, with the reflection from each surface of the glass reduced about ten times, flare and ghosts are reduced about a hundredfold, i.e., as the square of the reflection power of the surfaces.

From comparison of the exposure times in each of these figures, the treatment appears to have a little more than doubled the lens efficiency. Part of this apparent increase in speed is subjective. An increase of detail and especially of contrast results from the enormous reduction of the flare that ordinarily produces a fogged background in pictures taken with untreated lenses.

Comparison of apparent densities of the pictures gives a more quantitative measure of the effect. The measured densities of the photographic records of the large black and white cards show that treating the lens almost doubles the efficiency in many cases, and increases the contrast. The increase in contrast is most noticeable under the adverse lighting conditions that ordinarily cause a large amount of flare and ghosts. The added transmission causes white objects to appear whiter and the reduced flare causes dark objects to appear darker. The treatment of lenses also produced a noticeable increase in the detail of the pictures which is probably attributable to the reduction of flare.

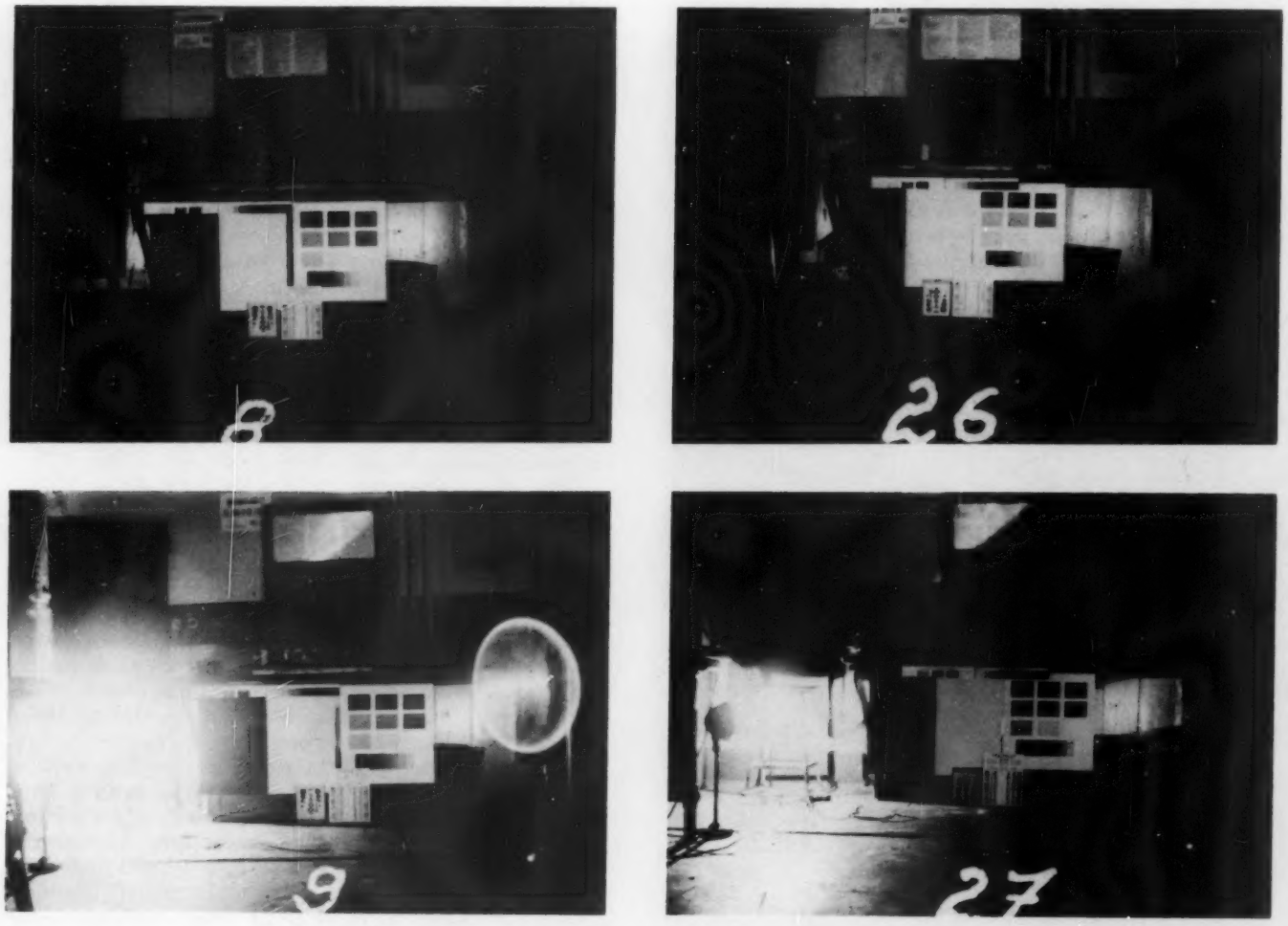
The Leica lens used for enlarging the pictures for publication was treated with evaporated films of sodium aluminum fluoride. The treatment produced an observable increase in contrast and detail in the enlargements, and, although the Leica lens had only three separated elements, the exposure appeared to be increased more than 60 per cent. Results similar to those already described were also obtained by treating faster lenses, but these lenses were so large that the quantitative results could hardly be of general interest. A picture taken recently in the Boston Garden by the *Boston Record* (Fig. 2) with a treated lens demonstrates that normal lighting gives a more natural effect than when flash lights are used and also that rather sharp pictures of the overhead lights were without the usual flare and ghost images.

One of the most interesting applications of the treated lens to photography is that made by Donald H. Menzel of the Harvard Observatory. In the coronagraph picture used as an illustration, the improvement effected by the treated lens is readily evident. These pictures were taken by first producing an image of the sun on a disk and then photographing the under side of the disk.

The tests made on several camera lenses indicate that the following results could be attributed to the film treatment of the lens: (1) an increase in the effective speed of 60 to 100 per cent, (2) a slight increase in contrast because of the absence of flare under normal lighting conditions and a large increase in contrast under adverse lighting conditions, (3) an observable increase in detail attributable to the absence of flare, and (4) the elimination of ghost images under adverse lighting conditions.

Figure 4. Schneider-Kreuznach Xenon f:2 F=5 cm. Stop f:3.5

BEFORE *AFTER*



FACTS vs. THOUGHT

Eastman Kodak

HOW CAN AMERICA MOULD ITS OWN PURE SCIENTISTS?

By A. J. SHALER and H. T. MARCY

"IT IS well known throughout the world that today American science leads the world in most of its branches. Never before in history . . . ": we too could speak for hours after a dinner meeting. But not far beneath the surface there seems to be another story. If, in pure science, America leads the world, perhaps it is significant that most of the "pure American scientists" are foreign-born, were educated elsewhere, and contributed their outstanding achievements before they were called to help fill the American vacuum. Einstein, Bethe, Franck, Goudsmit, Uhlenbeck, Fermi, Chandrasekhar, Ladenburg, the list is long in physics, as long in chemistry, longer still in some less well developed fields. Could it be that American education of young Einsteins throttles their success at the start? Or should we accept the idea that 1.3×10^8 Americans cannot produce?

What would happen if the supply of foreign-born scientists were suddenly cut off? Such a situation is not in the realm of speculation — it is here, now. The German and Austrian schools, the institutions of France, England, to a lesser extent the source that was India, and the supply from Italy, all are decayed, defunct, dead. If the level of American science is not to drop as a result, some improvement is obviously in order.

Let us see what could be done to bring forth from among American youth a more vigorous group of these thinkers, research men, theorists. In the following columns we are concerned strictly and uniquely with pure scientists, as distinguished from "applied scientists" and their associates, the engineers. Since baby Einsteins form but a small proportion of those whose education is undertaken by scientific and engineering schools, the improvement should preferably not transcend the present limitations of these institutions. With this in mind, a general study of some of the faults and their possible remedies may be made.

What is a good "pure scientist"? One who knows all the formulas? Then the Nobel Prizes should be awarded to the International Critical Tables and to the Handbook of Chemistry and Physics. A good scientist need not be a genius — the history of science mentions but a few of these. It may be significant that a great majority of those who produce the "revolutions" in science do not look up the literature on a question until after they have thought over, absorbed, moulded their problem, and constructed a working structure. This structure is the child of a mind marked by originality, imagination, ability, and above all these, interest. Such a mind is a master of the fundamentals, and knows that the details may be found in print when needed. He whose skepticism and resistance have been beaten down by the sincerity, loquacity, and logic of his predecessors, he whose mind is filled up with a detailed knowledge of all that has been done cannot possibly

(*Continued on page 229*)

EDITORIALS

Editor's Note: Believing that the student viewpoint of the international situation is smothered beneath the great mass of contemporary literature, the TECH ENGINEERING NEWS *herein presents two opinions of war and its relation to the Technology student.*

MILITARY SCIENCE?

War: we hate the thought of it. We hate the thought of Christian men needlessly murdering themselves in battle. We hate the thought of the broken families and homeless millions which result from a war. The fact that people of our modern civilization continue to act like the barbarians of old and continue to fight wars is to us needlessly stupid. We are against war in every way.

I believe that all of you, besides being against war, would like to abolish it. Do you attempt to do so? Does the average person approach the problem of war as scientifically as he would any other problem and thereby attempt to discover a solution for it? Evidently he does not. Throughout the Institute, through courses in Military Science men are led to believe that war is inevitable and that it is a riddle which cannot be solved, and they are scientific men who at the same time have been taught that every problem has a solution. It is all so completely wrong.

What has been said so far is somewhat idealistic; you will be able to pick it apart and see that it is emotionalistic. It is the viewpoint of a pacifist, and indeed, in these troubled days, such a viewpoint is somewhat out of style. I shall approach the problem more factually.

I have asked many Tech students what they think of Military Science. By and large they tell me that they consider it a "good thing," and are glad that they have been given a chance to take it. Upon inquiry I find that they have two reasons for thinking this way. (1) They believe that Military Training will give them a chance to be commissioned as officers in the Army at the time of the next war so that they will be better off than the common man, and will be put in a position where death is unlikely. (2) They believe that through the study of Military Science they will be able to best serve their country during a war. The following statistics will be of interest in our discussion. They are quoted from the Alumni Journals of the respective institutions published directly after the last world war.

	Harvard	*Boston University*	*Massachusetts Institute of Technology*
Enlisted Alumni (Army and Navy)	11,319	1,253	4,897
Per Cent Officers (Approximate)	40	50	52
Per Cent Killed	3	2	2.5

Tech was the only one of these universities which had required Military Science for its undergraduate body during the 40 year period preceding the war. Would Military Science at B. U. or at Harvard during this period have prevented more than three per cent of their enlisted alumni from being killed? Would Military Science have made it possible for more than 45 per cent of the enlisted alumni of these colleges to be officers? These questions deserve consideration — think them over.

I am of the firm belief that a Military Training course would not have altered the situation at all. After all, the military training Institute students receive amounts to practically nothing; what little you learn is forgotten in a year, and the material could be assimilated by anybody else in a month of study.

Every one of you at M. I. T. who dreads war nevertheless has one advantage over the common man which has probably been overlooked — you have been trained to be scientists. War is a scientific procedure; governments engaged in war want scientists, and when war comes your government will want you. During the last war the Government had 2300 former Tech students working in its civilian ranks. In the next "superscientific" war it will employ even more. Once you are working for them, mixing chemicals, designing bombs, manufacturing guns, or whatever it may be, you may be well assured that they will take good care of you.

Because many Tech students will be employed, during the next war, in civilian ranks, and because those students who are forced to go to war will find that their Military Science Training has not benefited their status, I should like to see the course in Military Science at Tech abolished. In its place should be substituted a course from which students can obtain some benefit; a course, and I am perhaps being a little idealistic now, which will teach them how to approach war as a problem rather than as an unsolvable riddle.

PROPAGANDA

"We'll be at war within a year," is the fatalistic conclusion reached in most informal discussions of international affairs. The young people of the country apparently oppose, and at the same time bitterly resent, the possible entrance of this country into the European war. However, do they not feel that such abstinence is impossible in the light of past experience? Propaganda and mass psychology have performed seeming miracles of reversal before this and never have the methods of dissimulation approached their present heights.

Let us see how these two factors have played their parts at a place supposedly well filled with intelligent specimens of the human race. A 1917 newspaper clipping reveals that the war fever of the Institute had been worked up to such a pitch that a senator of the United States Government was hanged in effigy because he opposed the entrance of this country into the world-wide conflagration. This was done by Tech men; and the only student who objected to the proceedings was mobbed. Does this reveal sane and sensible reasoning on the part of the men enrolled here at that time? No, probably it does not. But they are not wholly to blame for such an episode, since, by hindsight, we see it was merely one manifestation of a well planned and executed system of propaganda and mass psychology.

Long before the decision to enter the last world war was made by the Government, the general public was being adequately prepared for just such action. Propaganda was spread throughout the entire country, and, while everyone would have vigorously denied that such a thing existed, its efficiency is obvious and at

(*Continued on page 228*)

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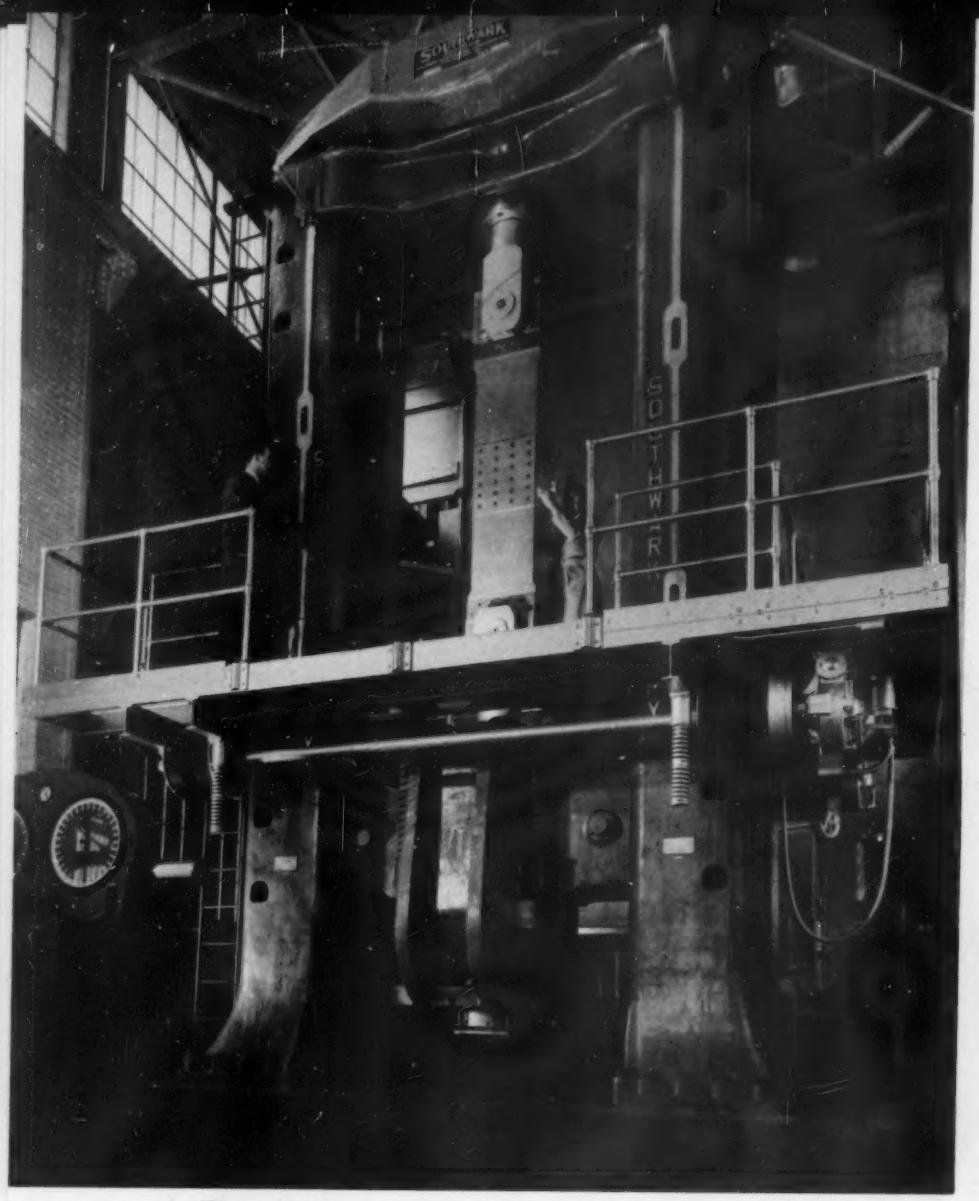


Figure 1. *Aluminum Company of America*

ENGINEERS' THIRD DEGREE

NEW TESTING MACHINE DEVELOPS POWER WITH HIGH PRECISION

EARLY last month the field of testing materials was endowed with a machine which engineers suspect will add greatly to the success of metallurgical research in the future. This latest contribution is the work of the Baldwin-Southwark Corporation, and will see service in the Aluminum Company of America's research laboratories in New Kensington, Pa. Although this new work does not outrate other similar machines, it embodies certain features which, if not exclusive, are at least exemplary of the equipment which the scientist employs today in the never-ending task of testing materials.

The most important task of this new testing device will be the determination of the practicability of new alloys and new designs. It will attempt to increase the uses of one metal in particular — aluminum. Those who have followed the success story of this metal as it has grown from an expensive, unimportant product to one of the most versatile materials in existence, can see in this contribution the beginning of a new chapter in the story. Alloys of aluminum are used in products which vary from automobile license plates to the internal structures of heavier and lighter-than-air-craft.

The development of new alloys suggested the need for the testing machine. In the process of perfecting each new type of alloy, it is subjected to the mechanical engineer's most gruelling "third degree." The metal must prove its worth by behaving satisfactorily under tests which reveal accurately the yield strength, tensile strength, elongation, and fatigue strength. This machine can subject the metal to reverse bending, torsion, tension, and compression — all in a satisfactorily exact manner — thus disclosing the characteristics of the metal by methods which suit the metallurgist's requirements. Not so much as an unusual feat, but more as a demonstration of the machine's destructive pulling power, this testing machine neatly sheared forty-eight closely spaced, three-quarter inch rivets which connected a pair of half-inch steel plates. However, apart from being a "machine of destruction," the device possesses certain constructive features in that means are provided by which the device can be con-

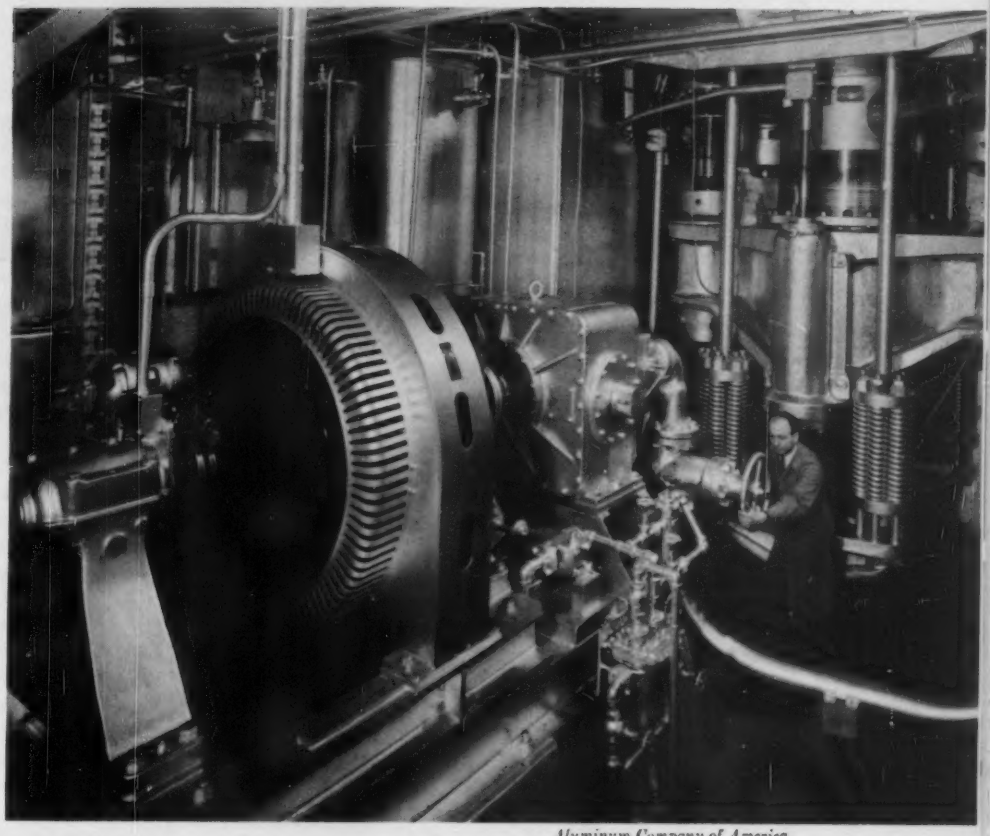
verted into an extrusion, forging, forming, or stamping machine. The relationship existing between the various forces involved in the plastic flow of aluminum throughout a wide range of conditions is defined through the accompanying suitably calibrated recording meters. In the construction, special attention was given the "manipulating" features, thus providing a suitable means for measuring and recording loads through these meters.

The device has gained the distinction of being the "most powerful" because it can operate at speeds up to thirty-six inches per minute (power being force times speed). The maximum forces which can be exerted are 3,000,000 pounds compression and 1,000,000 pounds tension. (Compare with University of Southern California's 4,000,000 pound machine, also built by the Baldwin-Southwark Corporation.)

The new machine itself is some three stories high — forty feet and four inches to be exact. It is sixteen feet and four inches wide, and from front to rear it measures nine feet. (Figure 1.) In compression testing an area of ninety inches by 108 inches is available; the maximum height for such a condition is 186 inches. When in tension testing, a thirty-six inch stroke is possible, and 150 inches are available for the sample to be tested. When necessary, however, the heads of the machine can be adjusted to exceed the ordinary height.

From the "basement" comes the power. (Figure 2.) For ordinary testing, a pump, operated by a twenty h.p. motor, delivers eighteen gallons of oil per minute to the base of the hydraulic ram. For high speed testing, the ram, forty-six inches in diameter, is elevated by 270 gallons per minute of oil, which enters the chamber from a pump operated by a 300 h.p. motor.

It is interesting to note that the speed of the machine makes it possible to pass the yield point of a specimen in less than one second and to cause the specimen to fail in less than fifteen seconds.



Aluminum Company of America

Figure 2. The operating machinery showing motor and pump.

Those familiar with the present scope of the testing materials field will realize from a consideration of the facts pointed out here that no revolutionary improvements are offered by the machine. However, by considering the features embodied in this one device, the average observer may gain an insight into the problems of the designer and his most logical method of attack from the practical standpoint.

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EDITORIALS

(*Continued from page 224*)

that time little thought had been given to the best means of propagation. Rumors got about that the Germans were commiting atrocities which would shock the civilized nations. Americans believed that the world could never be safe as long as a particle of Prussian pride and arrogance existed. From this it was but a short step to controlling the nation's presses and getting them to print only such articles as upheld the popular opinion. At this time the whole procedure was being carried on nationally, but not one person in a thousand was aware of what was happening. Everyone was eager to agree with his neighbor. Here mass psychology was working. No one enjoys being different from his fellows and especially on a subject as touchy as the possibility of America's entrance into the European War. We as a nation have come a long way since the 1917 era. But have we outgrown or defeated the influence of efficient propaganda? Probably not.

Propaganda makes the wheels of this country roll and we would be lost without it, but it is true as well that we would perhaps not be so quick to distinguish wrong from right in what we hear. To suppose that we as a nation or even we as students in a leading technical school can differentiate between true and false propaganda as it is supplied to us is an impossible supposition. The propaganda machines of this and other countries are in better shape than they have ever been previously. They are well oiled and are working overtime. Propaganda supplies a sugar-coated idea, makes it popular, and then, by judicious application of fuel to the ever increasing passion of the masses, lets mob psychology take its course. Before anyone actually knows what has happened war may be declared and we are supporting with all our energy what we ardently opposed a short time before.

Such is the inevitable conclusion when the world propaganda machine begins to roll with an accent on war. Why is there any reason to suppose we will be more intelligent this time than we were last? It is a sad prospect if we do not keep our wits, and, unless we are careful, it is the inevitable one. As a student body we can keep out of such an hysteria if we so desire, but it will take a careful sifting of what we hear to distinguish which is fact and which fable. Pessimism because of past experience is surely present at M. I. T., but that is by no means any reason to despair of the future. If the United States declares war this time we have only ourselves to blame — we have been warned often enough.

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FACTS vs. THOUGHT

(*Continued from page 223*)

doubt, and, not doubting, cannot improve. Is it not just such detailed knowledge that the American schools strive to cram down the throats of their students? Rather than to teach the formulas, data, and results obtained by others, would it not be preferable to emphasize the mental processes, the methods of attack, the errors, the difficulties of those who have contributed? The educational system is supposed to be devoted to training the minds of the students, not to filling these minds with the contents of monographs as if the latter were in imminent danger of disappearing.

Ability, it was stated above, is one of the hallmarks of the researcher. Is ability a function of knowledge? No, ability can better be increased by teaching the student to profit by the errors of others, to gain insight into the possible channels of thought of his own mind by following the thoughts of others; in short, to know himself and the problems he will have to solve, so that in the future he may put the two together and produce a worth-while result. The student knows he can read; he knows where there is a library and how to find a book in it; he knows where the index is. What he does not know is what his own mind can do, and what is to be done. As long as it cannot be put on the network analyzer, the only way to teach him what his brain can do is to show him what other brains have done, and how they went about doing it, and what they needed in order to do it. It would indeed be an insult to our teachers to intimate that they cannot teach him this. And yet the present system does not, it seems, permit them to show that they can. "Magnificent" is the word for the way the American schools put the tools of research into the students' hands. They fail to add the essential datum of how to hold these tools. Far more able is he who knows what the tools are for, how to use them; he can make his own, then, without any trouble.

Imagination — that is another one of the hallmarks mentioned, and originality goes hand in hand with it. Now, can a student acquire these when he lives in the same building with a regimented teaching staff, teaching him from standardized textbooks, his time completely filled with a standard curriculum, that of his teachers with standard requirements? It is possible that engineers may be created by mass production, but one whose chief asset in life will be that he differ from others must be custom-built, even hand-made.

Most of the making is contributed by the student himself. Since he is not an experienced "maker," it is the duty and the function of the teachers to guide carefully this manufacturing process. And what happens? He is flooded with home problems to solve. After a few months he knows what it is expected that he shall do with those home problems: look into the particular text

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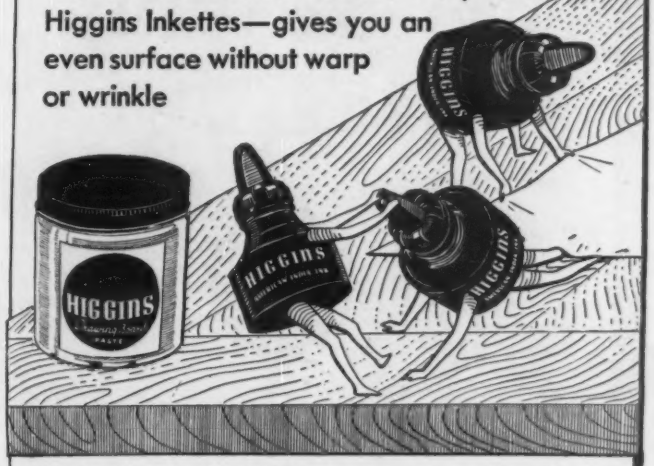

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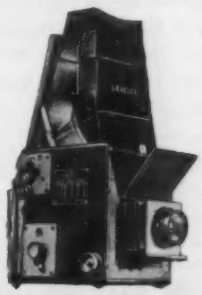

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that has been assigned, at the chapter under consideration at the time, and find a formula that appears to fit the data; go through the solution in the same manner as that presented. Time: *a* hours, *b* minutes, *c* seconds. At the next recitation period (there are any number of these) his teacher, who has done the problem before, states that: "this is the way to solve the problem. . . ." Originality? Imagination? Where? If the student were given a little time, to savor the problem, to see the various methods whereby he could arrive at a solution, to wonder at the meaning of it, to perceive how his mind groped, erred, and finally succeeded, then he would have learned something real, something useful. Failing to solve it, he would see how others succeeded, find out from his teacher what the possible methods are.

But no, that is not to be. For his teachers themselves

(*Continued on page 232*)

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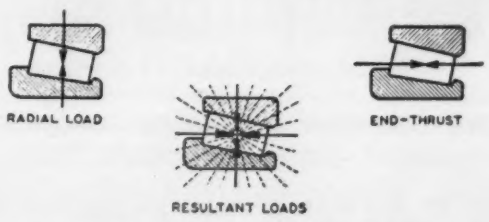

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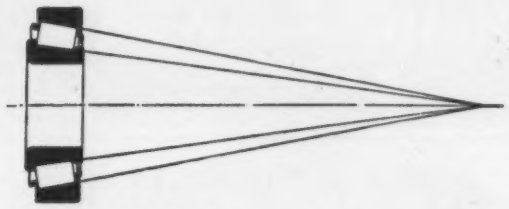

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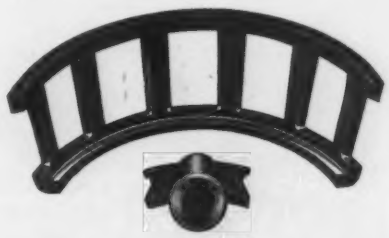

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FACTS vs. THOUGHT

(*Continued from page 230*)

are subject to the "poundage law"— they must produce so many printed pages per year, so many students per year, so many 100's, so many 90's, so many flunks per year. Can it be wondered then why the students of these teachers should have to produce so many solutions to problems per year? In some cases the "poundage law" might aptly be called "tonnage law," so demanding is it. And it is a discouraging prospect for the student of science to know that when he emerges from school with a Ph.D. at the end of his name he will immediately come under the destroying poison of this law.

Having destroyed, let us now see how we can go about reconstructing. In certain Swiss universities, in Belgian high schools even, there has been talk of doing away entirely with home work. At such a radical (for a modern American school) experiment as St. John's College, the familiar home problem has all but disappeared, and the study of science is the study of the minds and writings of those who contributed to it. Perhaps these methods are rather extreme — that may be argued elsewhere — but they indicate the extent to which a reform may successfully be carried.

In several other institutions of higher learning another movement may be discerned: the honors-group system, wherein the student has complete freedom to follow up those questions which activate his mind, to let his imagination run within wide limits, and, most important, to "use" his teachers, asking questions and being guided when and where he needs answers and guidance, not on the nth day of the nth week. Some argue that honors-group students tend to wander down narrow alleys, fail to acquire a broad view of their field. Others insist that the difficulty lies in making them

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reduce their interest to fewer questions so that they may probe more thoroughly into each. It is evidently a question of adjustment in the guidance of the student, and more experience should improve the situation. In general, the system has been successful, and the fact that such a system should be successful in the upbringing of young engineers makes it practically a requirement in the case of young scientists.

And given the opportunity to digest, to extract from the knowledge and wisdom and experience of his teachers all that can be extracted, to let his imagination have the exercise it needs (the libraries, laboratories, help and guidance provided by the existing institutions furnish him with the tools he needs) the student cannot possibly lose interest in what he is doing. To a humanity that can give him this he in turn will give all he has to give. It is Utopia, and there is no reason why, for once, Utopia may not be attained.

What is to keep his interest aroused at present? His mind is bewildered because he does not have the time to appreciate the aims and intentions of his teachers.

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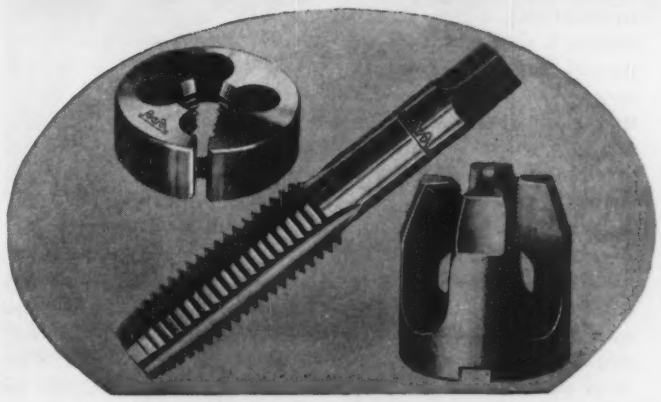

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Faced with a really juicy morsel, he is immediately dragged away from it because the schedule does not provide for more of the same. When he perceives the possibility of further delights in the small opening the teacher has cleaved for him, he cannot take another look — it is not a part of the course, and there are enough problems due next week to keep him busy all day. Must there be a set number of problems, so that from the number of right answers and the number of wrong the teacher can compute the average and produce a grade? Would not the grade mean so much more if it were the result of weighing the possibilities of the student in terms of one large paper, for instance, in which he had incorporated all the best that is in him? Must there be a grade? Is one man so many per cent better than the next, or is he "excellent," "good," "fair," or "poor"? It is discouraging to be graded mechanically by a teacher who has not taught you, and who does not even know you. For just so long as the teaching is subordinated to the poundage of printed matter put forth into the literature, just so long will the teacher have no time to learn to know his students. Great minds there are among his teachers; minds infinitely more mature than his own, and yet the student must see them as textbooks wired for sound, which he cannot stop, cannot start, cannot cause to deviate from the standard path. That is the picture of an enemy, not of a friend from whom he can acquire wisdom and expect understanding.

Teachers should be teachers, not something else. It is not true that the best research men make the best teachers. Teaching is the application of something that is already known; research is the search for something new. Why then should the teachers be required to spend their time contributing more printed pages to a literature that is already cluttered up with immature ideas and redundant data? Perhaps it is because our institutions strive toward making teaching pay for research — they used to call this "the search for perpetual motion!" When the institutions will finally recognize the difference between their teaching staffs and their research staffs, then and then only will the student learn to love his work, to become absorbed in its possibilities, and learn to derive profit from the privilege of being in the proximity of men far wiser than he and willing to open to him the book of their experience. The teacher knows what the research staff is doing, what men know what, where information may be secured. That is his function, and it is this knowledge and his wisdom that he must use to guide the maturing mind. And why should such a situation not exist? The men in American institutions are entirely capable of filling this function. In so doing they will contribute far more to the advancement of science, and in addition they will have the respect and love of the student; he in turn cannot then lose interest in his work.

With the requirements of scheduled problem work reduced, the student is free to give time to discussions with his fellow students. Where better can he learn to gauge his progress, where better to spot the difficulty he feels but cannot define? There is no end to the benefit the student could derive from frequent conferences with his instructors, and frequent seminars with his fellows, under the guidance of the teachers. Surrounded with real friends fired with the zeal of progressing, he cannot possibly fall into discouragement. With education directed towards improving the student's ability, rather than towards making of him a walking Britannica, it would be but a matter of a few years before the American scientific schools would replace and outdo the dying foreign sources of Einsteins and Platos and Newtons.

The question rises imperatively now of how to go about setting up such a revitalized system. First and hardest to solve is the problem of how to get rid of the "poundage law." It is an ingrown evil, and like cancer cannot be eradicated by surgery. But should the schools recognize the difference between teachers and research men, and relieve the former of their production requirements, it will automatically follow that the students, growing to positions of greater influence, will soon raise the level of publication to the point where once again twenty-four hours a day will suffice for a man to keep up with the literature in his field.

Next follows the question of where to start cutting down on the homework requirements. Instead of the host of pre-solved end-of-chapter problems, there would be substituted a restricted number of more difficult and more general problems, chosen not by the teacher alone, but in student-teacher consultations. It has been the experience of teachers in assigning difficult problems that some students give up trying to solve them, others never get anywhere with them in spite of worrying about them forever, and only a few derive profit from them. But is not this last our group of eager young scientists, imaginative, able, and interested?

The decrease in number of the problems will also reduce the time in recitations. To set up in place of these more seminars should prove of no difficulty, and the experience of the honors-group system should provide sufficient guidance in this respect. If difficulties be encountered in making up examinations, these may be made oral, or in any case more general, or completely done away with. A series of term papers, or minor theses, could take their place. From the construction of these papers and theses it would follow that the student would more and more often consult his teachers, and hence the required improvement in teacher-student relations would automatically come about.

May we insist here again that we deal with the education of young "pure scientists," and not with that of young engineers or "applied scientists." And here we encounter what is perhaps the most difficult part of all. For how and when are the students going to be chosen? How should they know at the tender age of seventeen or eighteen whether they wish to become "pure scientists" rather than engineers or artisans or artists? How shall the institution determine whether they are qualified to be admitted into this order? The question has been solved before. The solution is based on the concept that the qualifications of a lad of that age do not restrict him to one narrow specialization, nor do his desires and interests lead him incontrovertibly into one channel. Furthermore the system itself is sufficiently flexible — remember, the student's imagination is allowed full scope — to permit him to organize his intentions and aims far more successfully even than at present, since now he must make an arbitrary choice after two years as to which type of standardized courses he will listen to for the succeeding years. He is being offered not a choice of elective courses, but rather a generalized tour of a vast field, in which he may explore to his heart's desire, guided always. Perhaps, then, at any time after the end of his first two years, it might be made possible for the student, after thoroughly talking the problem over with his teachers, to decide whether or not he wishes to apply for admission into the new system, and for his teachers to determine whether or not he is qualified to do so. The time consumed in preliminary scientific studies is usually seven years. Let us use at least the last five of these toward making the student think rather than remember.

RIGHT OR WRONG?

A 2-minute test for telephone users

1. It's impossible for you to telephone to people in two different cities at the same time.

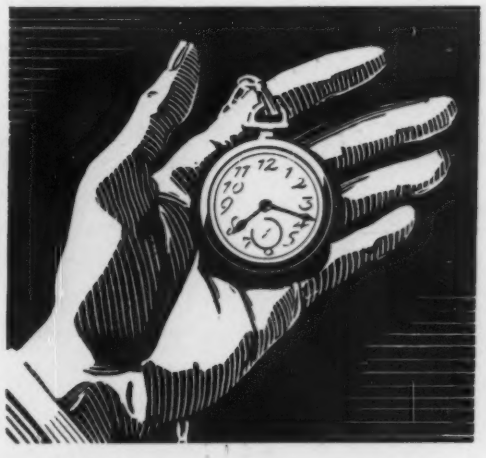
RIGHT ☐ **WRONG** ☐

2. Police Radio Telephone made by Western Electric is an outgrowth of research at Bell Telephone Laboratories.

RIGHT ☐ **WRONG** ☐

3. About 75% of the Bell System's 85 million miles of telephone wire is contained in cable.

RIGHT ☐ **WRONG** ☐



4. Lowest telephone rates to most out-of-town points are available every night after 7 P. M. and all day Sunday.

RIGHT ☐ **WRONG** ☐

ANSWERS:

1. *Wrong.* Telephone Conference Service enables you to talk simultaneously with as many as five other people.

•

2. *Right.* And that's true also of broadcasting equipment, aviation radio telephone and marine radio telephone.

•

3. *Wrong.* Over 95% is now protected by cable — nearly ⅔ of which is underground.

•

4. *Right.* Why not telephone home oftener? Your family will enjoy it—so will you!

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G-E Campus News

4400 TIMES HIS OWN WEIGHT

A MAN could lift four 100-ton freight cars if he were proportionately as strong as a new Alnico magnet assembly recently developed in the General Electric Research Laboratory.

The greatly increased strength of the new magnet is due to a special mounting, which permits the magnetic flux to pass through many air gaps instead of the usual two in bridging from pole to pole. This makes possible a more efficient utilization of the magnetic energy. In recent laboratory tests a magnet weighing only one quarter of an ounce was able to support 69 pounds—about 4400 times its own weight. This new development, although not yet commercially available, broadens the field of permanent magnet applications.

TWO OUT OF TWENTY

IN his selection of the 20 outstanding men and women of 1939, Durward Howes, editor of "America's Young Men," honored two General Electric leaders: Philip D. Reed and Katharine B. Blodgett.

Mr. Reed has been with General Electric since 1926. He received his engineering degree from Wisconsin in 1921 and his law degree from Fordham University three years later. In 1937 he became the assistant of Gerard Swope, President of General Electric. Mr. Reed is now Chairman of the Board of Directors.

Miss Blodgett was graduated from Bryn Mawr in 1917, received her M.S. degree from the University of Chicago, and spent the next six years in the General Electric Research Laboratory in Schenectady. In 1924 and 1925 Dr. Blodgett studied at the Cavendish Laboratory in Cambridge, England, where she received the degree of Doctor of Philosophy. Returning to the G-E Research Laboratory, she has since been engaged in the study of molecular films.

2,000,000 HORSES

EVEN in its heyday the Wild West would hardly have tried stopping a stampede of 2,000,000 horses. Yet the job of stopping 2,000,000 horsepower of electric energy has been assigned to the General Electric breakers installed at Boulder Dam, and they do the job in 1/20 of a second. And the relays which trip these breakers are even more versatile, for it takes them only 1/200 of a second to locate trouble and trip the proper breaker.

The power developed at Boulder Dam is carried to Los Angeles at 287,000 volts—the highest voltage in the world in regular service. Two transmission lines, running side by side, are used to span the 380 miles. To protect these lines required the development of circuit breakers capable of interrupting one and a half million kilowatts of power.

Student engineers, recent college graduates taking the G-E Test Course, had the responsibility of testing these circuit breakers in the Philadelphia Works of General Electric.

GENERAL ELECTRIC

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